CLAIMS

What is claimed is:

1. A magnetic element comprising:

a pinned layer;

a spacer layer, the spacer layer being nonmagnetic; and

a free layer having a free layer magnetization, the spacer layer residing between the pinned layer and the free layer, the free layer having a high perpendicular anisotropy and an out-of-plane demagnetization energy, the high perpendicular anisotropy having a perpendicular anisotropy energy being at least twenty percent and less than one hundred percent of the out-of-plane demagnetization energy;

wherein the magnetic element is configured to allow the free layer magnetization to be switched due to spin transfer when a write current is passed through the magnetic element.

2. A magnetic element comprising:

a first pinned layer;

a spacer layer, the spacer layer being conductive and nonmagnetic;

a free layer having a free layer magnetization, the spacer layer residing between the first pinned layer and the free layer, the free layer having a high perpendicular anisotropy and an out-of-plane demagnetization energy, the high perpendicular anisotropy having a perpendicular anisotropy energy that is less than a one hundred percent of the out-of-plane demagnetization energy;

a barrier layer, the barrier layer being an insulator and having a thickness that allows tunneling through the barrier layer;

a second pinned layer, the barrier layer being between the free layer and the second pinned layer;

wherein the magnetic element is configured to allow the free layer magnetization to be switched due to spin transfer when a write current is passed through the magnetic element.

3. The magnetic element of claim 2 wherein the free layer is a simple free layer.

4. The magnetic element of claim 2 wherein the first pinned layer is a first synthetic pinned layer including a ferromagnetic layer adjacent to the spacer layer, wherein the ferromagnetic layer has a first magnetization and the second pinned layer has a second magnetization and wherein the first magnetization and the second magnetization are oriented in opposite directions.

5. The magnetic element of claim 4 wherein the second pinned layer is a second synthetic pinned layer.

6. The magnetic element of claim 5 wherein the wherein the second synthetic pinned layer includes a second ferromagnetic layer adjacent to the barrier layer, wherein

the second ferromagnetic layer has a second magnetization, and wherein the first magnetization and the second magnetization are oriented in opposite directions.

7. The magnetic element of claim 2 wherein the first pinned layer and the second pinned layer are configured such that charge carriers both from the first pinned layer and from the second pinned layer can contribute to switching of the free layer magnetization due to spin transfer.

8. The magnetic element of claim 2 wherein the perpendicular anisotropy energy is at least twenty percent of the out-of-plane demagnetization energy.

9. The magnetic element of claim 8 wherein the perpendicular anisotropy energy less than ninety five percent of the out-of-plane demagnetization energy.

10. The magnetic element of claim 2 wherein the perpendicular anisotropy energy is ninety percent of an out-of-plane demagnetization energy of the free layer.

11. The magnetic element of claim 2 wherein the free layer includes Co, CoCr, CoPt, CoCrPt, CoFe, CoFeCr, CoFePt, and/or CoFeCrPt.

12. The magnetic element of claim 11 wherein an amount of Cr and/or Pt is adjusted such that the perpendicular anisotropy energy is at least twenty percent and less

than or equal to ninety five percent of the out-of-plane demagnetization energy of the free layer.

13. The magnetic element of claim 2 further comprising:

a seed layer adjacent to the free layer, the seed layer including Pt, Pd, Cr, Au, Cu, the free layer including Co, CoCr, CoPt, CoCrPt, Fe, CoFe, CoFeCr, CoFePt, and/or CoFeCrPt or a multilayer including Co, CoCr, CoPt, CoCrPt, Fe, CoFe, CoFeCr, CoFePt, and/or CoFeCrPt.

14. The magnetic element of claim 2 wherein the free layer includes Co, CoCr, CoPt, CoCrPt, CoFe, CoFeCr, CoFePt, and/or CoFeCrPt and wherein the magnetic element is configured to include an intrinsic stress of the free layer that provides at least a portion of the high anisotropy of the free layer.

15. The magnetic element of claim 14 further comprising:

a stress increasing layer on the free layer, the stress increasing layer including Cu, Au, Pt, and/or Pt.

16. The magnetic element of claim 2 wherein the free layer further includes:

a very high perpendicular anisotropy ferromagnetic layer; and

a ferromagnetic layer having a high spin polarization, the very high perpendicular anisotropy ferromagnetic layer for ensuring that a combination of the ferromagnetic layer

and the very high perpendicular anisotropy ferromagnetic layer have the high perpendicular anisotropy.

17. The magnetic element of claim 16 wherein the very high perpendicular anisotropy ferromagnetic layer includes GdFe and/or GdCoFe.

18. The magnetic element of claim 16 wherein the very high perpendicular anisotropy ferromagnetic layer includes a multilayer of [Co/Pd]n/Co, [Co/Pt]n/Co, [CoFe/Pd]n/CoFe, [CoFe/Pt]n/CoFe, [CoCr/Pd]n/CoCr, or [CoCr/Pt]n/CoCr where n is between 1 and 10, Co 3A to 20A, CoFe 3A to 20A, CoCr 3A to 20A, Pd 10A to 100A, Pt 10A to 100A.

19. The magnetic element of claim 18 wherein n is selected so that a total perpendicular anisotropy energy of the free layer is between twenty and ninety five percent of the total out-of-plane demagnetization energy.

20. A magnetic element comprising:

a first pinned layer;

a first spacer layer, the first spacer layer being nonmagnetic;

a first free layer, the first spacer layer residing between the first pinned layer and the first free layer, the first free layer having a first out-of-plane demagnetization energy;

a second free layer having a second free layer magnetization, the first free layer and the second free layer being magnetostatically coupled, the second free layer having a second out-of-plane demagnetization energy;

a second spacer layer being nonmagnetic;

a second pinned layer, the second spacer layer residing between the second free layer and the second pinned layer;

wherein the magnetic element is configured to allow the free layer magnetization to be switched due to spin transfer when a write current is passed through the magnetic element; and

wherein the first free layer is configured to have a first high perpendicular anisotropy having a first perpendicular anisotropy energy that is less than one hundred percent of the first out-of-plane demagnetization energy and/or the second free layer is configured to have a second high perpendicular anisotropy that is less than one hundred percent of the second out-of-plane demagnetization energy.

21. The magnetic element of claim 20 further comprising:

a separation layer residing between the first free layer and the second free layer, the separation layer being configured to allow the first free layer and the second free layer to be magnetostatically coupled.

22. The magnetic element of claim 20 wherein the first perpendicular anisotropy energy is at least twenty percent of the first out-of-plane demagnetization energy and/or the second perpendicular anisotropy energy is at least twenty percent of the

second out-of-plane demagnetization energy.

23. The magnetic element of claim 22 wherein the first perpendicular anisotropy energy is less than or equal to ninety five percent of the first out-of-plane demagnetization energy and/or the second perpendicular anisotropy energy is less than or equal to ninety five percent of the second out-of-plane demagnetization energy.

24. The magnetic element of claim 22 wherein the first perpendicular anisotropy energy is ninety percent of the first out-of-plane demagnetization energy and/or the second perpendicular anisotropy energy is ninety percent of the second out-of-plane demagnetization energy.

25. The magnetic element of claim 20 wherein the first free layer and/ or the second free layer includes Co, CoCr, CoPt, CoCrPt, CoFe, CoFeCr, CoFePt, and/or CoFeCrPt.

26. The magnetic element of claim 25 wherein an amount of Cr and/or Pt is adjusted such that the first high perpendicular anisotropy has a first perpendicular anisotropy energy that is at least twenty percent and less than or equal to ninety five percent of the first out-of-plane demagnetization energy and/or the second high perpendicular anisotropy has a second perpendicular anisotropy energy that is at least twenty percent and less than or equal to ninety five percent of the second out-of-plane demagnetization energy.

27. The magnetic element of claim 20 further comprising:

at least one seed layer adjacent to the first free layer and/or the second free layer, the at least one seed layer including Pt, Pd, Cr, Au, Cu and wherein the first free layer and/or the second free layer includes Co, CoCr, CoPt, CoCrPt, CoFe, CoFeCr, CoFePt, and/or CoFeCrPt or a multilayer including Co, CoCr, CoPt, CoCrPt, Fe, CoFe, CoFeCr, CoFePt, and/or CoFeCrPt.

28. The magnetic element of claim 20 wherein the first free layer and/or the second free layer includes Co, CoCr, CoPt, CoCrPt, CoFe, CoFeCr, CoFePt, CoFeCrPt and wherein the first free layer is configured to include a first intrinsic stress that provides at least a portion of the first high perpendicular anisotropy and/or the second free layer is configured to include a second intrinsic stress that provides at least a portion of the second high perpendicular anisotropy.

29. The magnetic element of claim 20 further comprising at least one stress increasing layer on the first free layer and/or the second free layer, the at least one stress increasing layer including Cu, Au, Pt, and/or Pt.

30. The magnetic element of claim 20 wherein the first free layer and/or the second free layer further include:

a very high perpendicular anisotropy ferromagnetic layer; and

a ferromagnetic layer having a high spin polarization, the very high perpendicular anisotropy ferromagnetic layer for ensuring that a combination of the very high

perpendicular anisotropy ferromagnetic layer and the ferromagnetic for the first free layer has the first high perpendicular anisotropy and/or the combination of the of the very high perpendicular anisotropy ferromagnetic layer and the ferromagnetic layer for the second free layer has the second high perpendicular anisotropy.

31. The magnetic element of claim 30 wherein the very high perpendicular anisotropy ferromagnetic layer includes GdFe and/or GdCoFe.

32. The magnetic element of claim 30 wherein the very high perpendicular anisotropy ferromagnetic layer includes a multilayer of [Co/Pd]n/Co, [Co/Pt]n/Co, [CoFe/Pd]n/CoFe, [CoFe/Pt]n/CoFe, [CoCr/Pd]n/CoCr, or [CoCr/Pt]n/CoCr where n is between 1 and 10, Co 3A to 20A, CoFe 3A to 20A, CoCr 3A to 20A, Pd 10A to 100A, Pt 10A to 100A.

33. The magnetic element of claim 32 wherein n is selected so that the first perpendicular anisotropy energy is between twenty and ninety five percent of the first out-of-plane demagnetization energy and/or the second perpendicular anisotropy energy is between twenty and ninety five percent of the second out-of-plane demagnetization energy.

34. A method for providing magnetic element comprising:

providing a pinned layer;

providing a spacer layer, the spacer layer being nonmagnetic; and

providing a free layer having a free layer magnetization, the spacer layer residing between the pinned layer and the free layer, the free layer having a high perpendicular anisotropy having a perpendicular anisotropy energy that is at least twenty percent and less than one hundred percent of an out-of-plane demagnetization energy for the free layer;

wherein the magnetic element is configured to allow the free layer magnetization to be switched due to spin transfer when a write current is passed through the magnetic element.